Biology and Management: A Review, Critique, and Research Agenda

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ABSTRACT

In this article, we conduct a systematic review of the emerging literature on the biological perspective in management and investigate research spanning the areas of genetics, physiology and neuroscience. We examine 291 papers published in 133 journals over an 85-year period, as well as ten conference/working papers and six books. Based on this analysis, we present an organizing framework of the area, explain the mechanisms through which biological factors relate to management, and discuss the implications of the biological perspective for the theory and the practice of management. Finally, we present an agenda highlighting avenues for future research in this field.

Keywords: Management; Genetics; Hormones; Physiology; Neuroscience

BIOLOGY AND MANAGEMENT: A REVIEW, CRITIQUE, AND RESEARCH AGENDA

What do we know about the role of biology in management? The past decade has witnessed a significant increase in the number of papers that address the ways that genetics, physiology, and neuroscience affect different aspects of management. As a result, we know far more than we once did.

However, our new knowledge is fragmented. "Much of this research has been published in journals that management scholars do not routinely follow, and the different studies themselves have been isolated from one another making it difficult to see the cumulative set of findings" (Shane, 2009: 67). Moreover, empirical work on the topic can be found across a large number of journals and in numerous subfields of management, which makes it difficult for management scholars to see how the same theoretical patterns are present in different subfields. Most importantly, the field of management also lacks a systematic discussion of how these individual findings relate to a broader theoretical perspective on how biology influences management, the different mechanisms governing each of these biological influences, and the links between them.

In response to this gap in the literature, we have systematically reviewed 291 papers published in 133 journals, four conference papers, six working papers, and six books/book chapters published over the past 85 years to review and synthesize the biological perspective in management. Based on this analysis, we present an organizing framework of this area (see figure 1) and explain the mechanisms through which biological factors relate to management.

Our review indicates that there has been a substantial amount of research on biological aspects of business. However, there has been little research that connects the three main biological strands to each other and no organizing framework for this biological perspective. Moreover, extant research does not take into account how environment and

biology jointly interact to influence management. Previous work has also neglected dynamic considerations, as evidenced by the lack of longitudinal studies. Furthermore, our review shows that research on the implications of the biological perspective for the practice of management is strikingly limited.

We begin our review by providing a detailed description of our methodology and review strategy. Then, we systematically synthesize the findings of previous studies on the biological perspective and describe the mechanisms through which biology relates to management. Finally, we identify avenues for future research and discuss the implications of the biological perspective for the practice of management.

Insert Figure 1 about here

THE BIOLOGICAL PERSPECTIVE

We define the biological perspective on management as the set of studies that examine: 1) genetic influences (Arvey, Li & Wang, 2016; Lindquist, Sol & Van Praag, 2015), 2) physiology (Heaphy & Dutton, 2008; White, Thornhill & Hampson, 2006), and 3) neuroscience (Becker, Cropanzano & Sanfey, 2011; Waldman, Wang & Fenters, 2016a). Taken together, these studies form the basis for a new school of thought that incorporates human biology into explanations of management behavior (Shane, 2009).

Although the past few years have witnessed the emergence of efforts to synthesize and review studies on each of the three subsets of biological factors, no reviews have sought to bring those different subsets together into a broader biological perspective. Because genetics, physiology and neuroscience jointly affect human behavior, it is important to consider how these factors collectively influence management (Shane, 2009). By offering a *systematic* review of these three areas, considering the mechanisms that govern each, and by

highlighting their effects together, we can begin to develop a comprehensive understanding of how biology influences management.

METHODOLOGY

Our review strategy is designed to provide a systematic and explicit method for reviewing all three biological aspects in management research. First, we identified keywords (search terms) related to the three biological factors which we then constructed into search strings (see table S-1 in the online appendix). Second, we followed the protocols outlined by Tranfield, Denyer and Smart (2003) for undertaking reviews in the field of management. Using these protocols, we searched the following databases: ProQuest, Thomson ISI Web of Knowledge and Scopus to ensure that we uncovered all relevant work. We then reviewed all studies published in journals listed in the ABS[1] list to identify every possible article that might be relevant to a review of the biological perspective on management.

While we began our effort to find articles written since 1900, the first article we found was that of Carter (1932) on the possible influences of genes on occupational choices. We included all articles written through the end of March 2017, the stop point for our study. We exported all the papers to Endnote where the studies were screened using title and abstract analysis to identify every paper that might be relevant to our topic. This effort yielded a total of 335 articles and one book chapter. Of these articles, 164 were then excluded according to our exclusion criteria (see table S-2 in the online appendix) leaving us with a total of 171 articles and one book chapter.

We then employed a backward and forward snowballing procedure by manually searching the reference lists of all included studies. This additional procedure increased the number of articles by 51 journal papers, 2 books, 2 conference papers and 1 working paper. These journal articles were also screened according to the inclusion and exclusion criteria using a title and abstract analysis. By following this approach, our review was not limited to

specific journals or authors who publish in this area, but included all articles cited by or which cited work in this area. This procedure is a precondition for a complete and exhaustive summary of the literature (Tranfield et al., 2003).

Finally, to ensure that we did not miss any articles, we included several papers based on experts' opinions. We showed our list of articles to three experts in the field and asked them to identify any papers that our procedure had failed to identify. This additional step yielded 5 more papers on genetics, 41 on physiology and 23 on neuroscience. It also provided two conference papers, 5 additional working papers, and 3 book chapters/books. After validating the search criteria against the retrieved papers, our overall search yielded a total number of 291 published journal articles, 4 conference papers, 6 working papers and 6 books/book chapters (see table 1).

Insert Table 1 about here

RESULTS

The results of our review show that the biological perspective has been studied in a number of subfields of management (see table S-3 in the online appendix). We show key journals contributing to the review in terms of their coverage of this area in figure S-1 in the online appendix. The review shows that 56% of the studies are empirical and 44% are conceptual. The majority of retrieved articles focused on neuroscience (115 papers), followed by physiology (109 papers), and genetics (77 papers). There are also two book chapters focusing on neuroscience, two book chapters as well as a full book investigating the role of genetics in management and one book examining the different biological predispositions to organizational behavior.

Findings of Genetics

A large number of the studies on the biological perspective focused on the role of genetics in management. In this review, we define research on genetics as the set of studies that examine the influence of factors that "are encoded in DNA and transmitted biologically" (Nicolaou & Shane, 2009: 2) on management behavior. Management scholars have sought to examine the genetic predispositions to management through two methods: (1) a quantitative genetics approach and (2) a molecular genetics approach. Our review shows that 77 percent of the genetics studies in management took a quantitative genetics approach, while 23 percent adopted a molecular genetics approach.

Quantitative genetics. The quantitative genetics approach identifies the relative proportion of the variance in a variable and the covariance between multiple variables that can be attributed to genetic and environmental differences (Plomin, DeFries, Knopik & Neiderhiser, 2012). With this approach, researchers have been able to disentangle the contributions of genes and environment across a wide variety of organizational phenotypes using experiments of nature, specifically studies of twins, and experiments of nurture, particularly studies of adoptees (Shane & Nicolaou, 2015a). In addition, this approach has recently started to examine how the relative contributions of genetic and environmental factors can change over time (Arvey et al., 2016; Li, Stanek, Zhang, Ones & McGue, 2016b).

The classical twin design compares the phenotypic resemblance between pairs of monozygotic and dizygotic twins to examine whether the phenotype is heritable (Polderman et al., 2015). A failure to detect differences between monozygotic and dizygotic twin pairs' resemblance in a phenotype would indicate that genetic factors do not play any role in explaining the variance of this phenotype. But if the resemblance between monozygotic twins is higher than the resemblance between dizygotic twins, then genetic factors influence this phenotype (Nicolaou, Shane, Cherkas, Hunkin & Spector, 2008a). This natural experiment

draws on the fact that monozygotic twins are developed from one ovum fertilized by one sperm, unlike dizygotic twins who are developed from two ova fertilized by two different sperms. As a result, monozygotic twins are genetically identical and dizygotic twins share, on average, 50% of their segregating genetic makeup (Plomin et al., 2012).

Studies of adopted children also enable researchers to examine the heritability of organizational phenotypes. Adopted children carry the genes of their biological parents and are exposed to the environment of their adoptive parents. The phenotypic resemblance between children and their two sets of parents indicates the extent to which this phenotype is inherited. If there is a phenotypic resemblance between children and their biological parents, then genetic factors influence this phenotype. Meanwhile, if there is a phenotypic resemblance between the children and their adoptive parents, then environmental factors affect this phenotype. By comparing both correlations, researchers can examine the extent to which genetic and environmental factors influence management phenotypes.

Twin studies have demonstrated that there are genetic predispositions to numerous management phenotypes, such as the tendency to engage in entrepreneurship (Nicolaou et al., 2008a; Nicolaou, Shane, Cherkas & Spector, 2009; Shane, Nicolaou, Cherkas & Spector, 2010b; Zhang et al., 2009b), opportunity recognition (Nicolaou et al., 2009; Shane, Nicolaou, Cherkas & Spector, 2010a), leadership role occupancy (Arvey, Rotundo, Johnson, Zhang & McGue, 2006; Arvey, Zhang, Avolio & Krueger, 2007; Johnson, Vernon, McCarthy, Molson, Harris & Jang, 1998; Li, Arvey, Zhang & Song, 2012), leadership emergence (Chaturvedi, Zyphur, Arvey, Avolio & Larsson, 2012; Ilies, Gerhardt & Le, 2004), transformational leadership (Chaturvedi, Arvey, Zhang & Christoforou, 2011), job demands, job control, social support at work, job complexity (Li, Zhang, Song & Arvey, 2016a), behavioral anomalies (Cesarini, Johannesson, Magnusson & Wallace, 2012), income (Zyphur, Li, Zhang, Arvey & Barsky, 2015) and job satisfaction (Arvey, Bouchard, Segal & Abraham,

1989; Hahn, Gottschling, König & Spinath, 2016; Ilies & Judge, 2003; Judge, Ilies & Zhang, 2012) (see figure S-2 in the online appendix). Three studies used samples of adoptees to show the heritability of an organizational phenotype: vocational interests (Betsworth et al., 1994), occupational status (Scarr & Weinberg, 1994), and entrepreneurial tendencies (Lindquist et al., 2015).

The findings of the quantitative genetics research have shown that genetic factors can explain, on average, the variances of organizational phenotypes in a range from 20 percent to 60 percent. In addition, most of the work suggests that shared environmental factors (environmental influences that twins in the same family have in common) account for negligible amounts of variances in organizational phenotypes, unlike unique environmental factors (environmental effects that differ from one twin to another) which were found consistently to be very influential. Simply put, the most important factor affecting the organizational phenotypes that people display is the non-shared environment, followed by their genetics.

Although studies of twins and adoptees have been successful in revealing the genetic influences on organizational phenotypes, these methods do not detect the specific genetic variants that contribute to the variations in these phenotypes. For that researchers must conduct molecular genetics studies.

Molecular genetics. The molecular genetics approach provides two powerful methods for identifying the specific genetic variants that influence organizational phenotypes: candidate-gene and genome-wide association (GWA) methods. The candidate gene approach is a hypothesis-driven design in which certain genes are, a priori, hypothesized to influence the variable under examination. Candidate-gene studies propose that a particular gene influences management based on its function. For instance, if genes influence certain physiological patterns associated with management phenotypes, researchers can hypothesize

that these predictor genes can affect their associated management phenotypes (Munafò, 2006).

Studies using the candidate-gene method have shown that the dopamine receptor genes are associated with entrepreneurship (Nicolaou, Shane, Adi, Mangino & Harris, 2011), leadership (Li, Wang, Arvey, Soong, Saw & Song, 2015), job changes (Chi, Li, Wang & Song, 2016), job satisfaction (Song, Li & Arvey, 2011), and exploration and exploitation (Frank, Doll, Oas-Terpstra & Moreno, 2009). Further evidence has also shown that the serotonin transporter genes are associated with corporate corruption (Kong, 2014) and job satisfaction (Song et al., 2011). The long-repeat polymorphism of the AVPR1a RS3 microsatellite was also associated with entrepreneurship (Wernerfelt, Rand, Dreber, Montgomery & Malhotra, 2012).

On the other hand, the genome-wide approach is a hypothesis-free design that involves investigating the entire genome (Koellinger et al., 2010; Yeo, 2011). It uses microarrays to genotype millions of single nucleotide polymorphisms (SNPs) on small chips in order to locate the genetic variants influencing organizational phenotypes (Plomin et al., 2012; Shane & Nicolaou, 2015a).

Increasingly, researchers are turning to genome-wide association studies (GWAS) to identify the genetic variants affecting management (Koellinger et al., 2010; Quaye, Nicolaou, Shane & Mangino, 2012b; van der Loos, Koellinger, Groenen & Thurik, 2010; van der Loos et al., 2013) because genetic research has shown that (1) GWAS are better than candidate-gene studies in detecting very small effect size genes expected for complex phenotypes in management without pre-hypotheses, and (2) they perform better in dealing with the polygenic nature of management phenotypes, where most phenotypes are influenced by a large number of genes rather than by a single gene. For example, in a GWAS, researchers have found an association between the rs10791283 of the OPCML gene on chromosome

11q25 and entrepreneurship at the 6 X 10^{-7} genome-wide significance level, which did not reach the 10^{-8} level of significance required for GWAS (Quaye et al., 2012b).

The molecular genetic studies show that organizational phenotypes are both polygenic and pleiotropic (Song, Li & Wang, 2015). Polygenic means that a very large number of genes are required to influence an organizational phenotype. For example, Belsky et al. (2016) found that polygenic scores derived from a GWAS predicted economic outcomes. Pleiotropic means that the same gene that influences one variable may also influence another; e.g. serotonin transporter genes have been associated with both job satisfaction (Song et al., 2011) and corporate corruption (Kong, 2014). .

Findings of Physiology

The second strand of the biological perspective has examined the role of physiology in management. Physiology is "the study of the normal functioning of a living organism and its component parts, including all its chemical and physical processes" (Silverthorn, 2001: 2) [2]. In this review, we define research on physiology as the set of studies that examine the relationship between hormones, physical characteristics, medical conditions and dimensions of management. The systematic review has retrieved a total of 109 papers on physiology and 3 books/book chapters.

Hormones. The first stream of research in the physiology strand has examined the influence of hormones in management. The most common hormones investigated in the social sciences include: (1) testosterone, (2) dopamine, (3) oxytocin, (4) serotonin and (5) cortisol (Narayanan & Prasad, 2015). However, within the field of management, empirical studies have only looked at two of these five hormones: 25 studies examined testosterone, while 12 studies have looked at cortisol[3]. This research has found significant associations between testosterone and numerous organizational phenotypes, such as entrepreneurial intention (Bönte, Procher & Urbig, 2015), self-employment (Greene, Han, Martin, Zhang &

Wittert, 2014; Nicolaou, Patel & Wolfe, in press; White et al., 2006), earnings (Gielen, Holmes & Myers, 2016), leaders' corruption (Bendahan, Zehnder, Pralong & Antonakis, 2015), entrepreneurial performance (Unger, Rauch, Narayanan, Weis & Frese, 2009; Unger, Rauch, Weis & Frese, 2015), perceived empathic accuracy (Ronay & Carney, 2013) and firm performance (Trahms, Coombs & Barrick, 2010) (see figure S-3 in the online appendix). These findings reveal that testosterone is an important, but often overlooked, factor in explaining power and status in organizations, by driving people's need to acquire additional resources and by stimulating competitive and retaliatory behaviors (Narayanan & Prasad, 2015).

Prior studies have also found a positive relationship between cortisol and work stress (Karlson, Eek, Hansen, Garde & Ørbaek, 2011), and a negative relationship between cortisol and leader's position (Sherman et al., 2012) as well as attained status in male executives (Sherman, Lerner, Josephs, Renshon & Gross, 2016). The influence of cortisol is "a double-edged sword" in the sense that cortisol may impair people's ability to perform and attenuate overall organizational effectiveness, but at the same time increase the likelihood that people attain leadership positions (Diebig, Bormann & Rowold, 2016: 684). Indeed, cortisol research has been rich in providing explanations about how managers handle stress in organizations and why some leaders perform better than others (Diebig et al., 2016; Mehta & Josephs, 2010).

While no research in management has examined the association between management and oxytocin, dopamine or serotonin, some studies have suggested potential relationships. For instance, oxytocin has been associated with self-esteem (Saphire-Bernstein, Way, Kim, Sherman & Taylor, 2011), which is a key predictor of several management phenotypes (Arora, Haynie & Laurence, 2013; Judge & Bono, 2001), including entrepreneurship and job satisfaction. In another example, dopamine has been associated with sensation seeking

(Nicolaou et al., 2011), which is associated with entrepreneurship (Nicolaou, Shane, Cherkas & Spector, 2008b).

Physical characteristics. The second stream of research in the physiology strand has examined the role of physical characteristics in management. Physical characteristics include "height, weight, physique, athletic, prowess, energy and energy level" (Arvey, Wang, Song & Li, 2014: 12). The systematic review has retrieved 33 empirical papers and 10 conceptual papers linking physical characteristics to management.

Empirical evidence has shown that physical characteristics including physical attractiveness and facial cues influence management phenotypes, such as entrepreneurial performance (Baron, Markman & Bollinger, 2006) and leadership (Alrajih & Ward, 2014; Doll et al., 2014; Little, 2014; Little, Burriss, Jones & Roberts, 2007; Re, DeBruine, Jones & Perrett, 2013; Re & Perrett, 2014). Researchers have also found a relationship between body weight (Agerstrom & Rooth, 2011; Cawley, 2004; Re, Dzhelyova, Holzleitner, Tigue, Feinberg & Perrett, 2012) and voice (Klofstad, Anderson & Nowicki, 2015; Klofstad, Anderson & Peters, 2012; Klofstad, Nowicki & Anderson, 2016) and various organizational phenotypes. For instance, Re et al. (2012) found that there is a negative relationship between leadership and body weight, explaining that a higher body mass index (BMI) raises negative perceptions about leaders' abilities which in turn influences their leadership. Klofstad et al. (2015) found that individuals with lower-pitched voices are perceived as strong, competent, and having high physical prowess and thus more likely to be selected as leaders than their counterparts.

The most studied physical characteristics were facial cues (19 studies) followed by body weight (7 studies). Facial cues and attractiveness were frequently related to leadership (Alrajih & Ward, 2014; Little, 2014; Little et al., 2007; Olivola, Eubanks & Lovelace, 2014), while body weight was related to hiring, earnings and leadership. Other work has linked

management-related phenotypes, including employment, leadership and job satisfaction to mouth width (1 study), body image (1 study), skin color (2 studies), voice pitch (2 studies) and height (3 studies).

Medical conditions. The third stream of research in the physiology strand has examined the role of medical conditions in management, including cardiovascular factors, diabetes and musculoskeletal conditions. The systematic review has retrieved 20 empirical and 9 conceptual papers. For instance, blood pressure (Ganster & Rosen, 2013; Ilies, Dimotakis & Watson, 2010; Lundberg & Frankenhaeuser, 1999; Melin, Lundberg, Soderlund & Granqvist, 1999), cardiovascular problems (Ganster, Fox & Dwyer, 2001; Ganster & Rosen, 2013; Matteson & Ivancevich, 1979; Schaubroeck, Ganster & Kemmerer, 1994; Schaubroeck & Merritt, 1997; Steffy & Jones, 1988), pain fluctuations (Christian, Eisenkraft & Kapadia, 2014) and musculoskeletal disorders (Manville, Akremi, Niezborala & Mignonac, 2016) were associated with workload, work stress and other occupational outcomes.

The most studied medical conditions were heart problems (20 studies), which were mostly associated with occupational and workplace factors. Other work has linked management-related phenotypes to diabetes (2 studies), occupational injuries (1 study), and musculoskeletal disorders (1 study). In combination, these findings reveal the role of medical conditions in influencing several work outcomes, including career choices, workload, job satisfaction and income.

Findings of Neuroscience

The third strand of the biological perspective focuses on the relationship between neuroscience and management (Hannah, Balthazard, Waldman, Jennings & Thatcher, 2013; Waldman, Balthazard & Peterson, 2011). This strand examines “how neuroscience can broaden our understanding of people at work and organizing processes” (Waldman, Ward &

Becker, 2016b: 9.2). "It involves the study of processes within the brain that underlie or influence human decisions, behaviors, and interactions either (a) within organizations or (b) in response to organizational manifestations or institutions." (Butler & Senior, 2007; Ward, Volk & Becker, 2015: 19). This is the most prominent area of the biological perspective as evidenced by the number of studies identified in our review (115 papers).

Although scholars in entrepreneurship (de Holan, 2013; Nicolaou & Shane, 2013), leadership (Hannah et al., 2013), human resource management (Becker, Volk & Ward, 2015) and other management areas (Becker et al., 2011; Butler, O'Broin, Lee & Senior, 2016) have started to recognize the value of neuro-scientific methods to organizational disciplines, it is surprising that we know very little about the role of neuroscience in management, as the literature is mainly conceptual: out of the 115 retrieved studies, we found 25 empirical articles incorporating neuroscience into management research.

Nevertheless, the empirical papers do show some patterns. Researchers have found that people with attention deficit hyperactivity disorder (ADHD)[4] (Thurik, Khedhaouria, Torrès & Verheul, 2016; Verheul, Block, Burmeister-Lamp, Thurik, Tiemeier & Turturea, 2015; Verheul, Rietdijk, Block, Franken, Larsson & Thurik, 2016; Wiklund, Patzelt & Dimov, 2016) and dyslexia (Logan, 2009) have a higher tendency to engage in entrepreneurial activities.

Other empirical studies have shown several associations between neurological activations in the brain and management. For instance, Dulebohn, Davison, Lee, Conlon, McNamara and Sarinopoulos (2016) found that the activations of the insula, ventral striatum, ventromedial prefrontal cortex and anterior cingulate cortex regions of the brain are associated with procedural justice, while the activations of the dorsal medial prefrontal cortex and the precuneus/posterior cingulate regions are related to distributive justice, with these findings varying from males to females.

In leadership, Waldman et al. (2011) found that the right frontal coherence is associated with the formation of a socialized visionary communication, which in turn builds followers' perceptions of the leader's inspirational capabilities. In another leadership study, Boyatzis et al. (2012) found that recalling experiences with resonant leaders was associated with the activation of regions such as the bilateral insula, right inferior parietal lobe, and left superior temporal gyrus, while recalling experiences with dissonant leaders limited the activations of the right anterior cingulate cortex and positively activated the right inferior frontal gyrus, bilateral posterior region of the inferior frontal gyrus, and bilateral inferior frontal gyrus/insula. Other qEEG findings have shown that being exposed to an inspirational leader activates the bilateral rostral inferior parietal lobule, pars opercularis, and posterior midcingulate cortex, while being exposed to a non-inspirational leader activates the medial prefrontal cortex (Molenberghs, Prochilo, Steffens, Zacher & Haslam, 2015).

Researchers have also demonstrated that the lateral occipital cortex, superior temporal cortex, medial parietal, subgenual cingulate, nucleus accumbens, and left lateral prefrontal cortex are activated by affect that may be provided by inspirational coaching and mentoring (Jack, Boyatzis, Khawaja, Passarelli & Leckie, 2013). Hannah et al. (2013) also found that a lower level of EEG coherence in the alpha frequency range in the frontal lobes is associated with greater adaptive decision-making, suggesting that both the frontal lobes in the brain and the adaptive decision-making are related to leader self-complexity. Other evidence has shown a significant correlation between job demand and oxygenated hemoglobin changes in the left dorsolateral prefrontal cortex in females, while greater changes in the right temporal cortex were observed among males (Kawasaki et al., 2015). Moreover, Waldman, Wang, Hannah and Balthazard (in press) found that the interaction of leader relativism and idealism partially mediates the influence of the brains' default mode network on ethical leadership.

In entrepreneurship, using fMRI, researchers found that entrepreneurs showed higher decision-making efficiency, and a stronger activation in regions of frontopolar cortex than managers (Laureiro-Martinez et al., 2014). Activations of the ventral tegmental area, substantia nigra, ventral striatum, nucleus accumbens, and ventro medial prefrontal cortex brain regions were associated with exploration. On the other hand, activations of the dorsolateral prefrontal cortex, locus coeruleus-norepinephrine circuit, frontopolar cortex and inferior parietal lobule were associated with exploitation (Laureiro-Martínez, Brusoni, Canessa & Zollo, 2015).

MECHANISMS

In this section, we explain the mechanisms through which biological factors may affect management: direct effects, mediation through psychological factors and attitudes, biology X environment interactions, biology X environment correlations, interactions within biological strands and interactions between biological strands. The overall pattern is presented in figure 2.

Insert Figure 2 about here

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1. Direct Effects

Biology may directly influence management. For instance, blood pressure problems, increased heart rate, immune system disorders and coronary heart diseases may result in poor productivity and high job turnover rates (Ganster & Rosen, 2013; Zhang & Zyphur, 2015). Evidence also indicates that genetic factors may act as antecedents to other biological factors that influence management. Nicolaou and Shane (2009) argued that genetic factors may affect hormones, brain functions, and appearance, which in turn influence management. For

instance, researchers have suggested that genetically influenced testosterone may influence the tendency of people to engage in entrepreneurship (Shane & Nicolaou, 2015a; White et al., 2006; Zhang & Zyphur, 2015). In physiology, Zhang and Zyphur (2015) have indicated that variations in hormone levels are related to cardiovascular processes and changes in the functioning of the immune system which may affect work outcomes, such as burnout and productivity.

2. Mediation through Psychological factors and attitudes

Biology may influence management through psychological factors and attitudes. In genetics, research has shown that genes may influence entrepreneurship, leadership, vocational interests, work values, job switching, and job satisfaction by affecting individual attributes, such as psychological traits, attitudes, and preferences (Arvey et al., 2016; Shane & Nicolaou, 2015a). Numerous studies have shown that neuroticism, extraversion, conscientiousness, openness to experience, agreeableness (Shane et al., 2010a, b; Zhang et al., 2009b), proactivity (Li, 2011), rule breaking (Li et al., 2015) and cognitive abilities (Arvey et al., 2006; Chaturvedi et al., 2011; Schermer, Johnson, Jang & Vernon, 2015; Shane & Nicolaou, 2015b) mediated the relationships between genes and organizational phenotypes.

In physiology, researchers have suggested, for instance, that hormones may influence people's attitudes toward competition, fairness, and trust which in turn affect organizational decision making (Narayanan & Prasad, 2015). There is also some evidence that hormones affect people's choice to become entrepreneurs. White et al. (2006) found that testosterone influences the tendency of individuals to become self-employed through risk taking. In line with this evidence, Bönte et al. (2015) indicated that the relationship between prenatal testosterone exposure and entrepreneurial intention is mediated by both general risk-taking and domain specific risk taking (e.g. professional career and financial investment).

Consistently, researchers have shown that positive affect mediates the effect of entrepreneurs' physical attractiveness on the evaluation of their ideas (Baron et al., 2006). Similarly, several scholars have found that facial cues influence people's beliefs which in turn affect leadership choice, and occupational success. For instance, Little (2014) suggested that leaders are partly chosen based on their faces as people believe that certain facial cues reflect specific abilities that are well suited for particular leading positions.

In neuroscience, Hannah et al. (2013) have suggested that the influence of the frontal lobes of the brain on leadership adaptability may be mediated by leaders' psychological self-complexity. In another recent qEEG study, Waldman et al. (in press) found that the role of brains' default mode network in predicting ethical leadership may be mediated by the interaction of leader relativism and idealism.

3. Biology X Environment interactions

The biological influence on management may be contingent on the presence of environmental factors. In genetics, research has labeled this pathway as gene X environment interaction (Rowe, 2003). Researchers, for instance, have found that genetic factors interact with social environment to influence the tendency of people to occupy leadership roles (Zhang, Ilies & Arvey, 2009a) and that unfavorable family environment in childhood lowers the genetic influence on entrepreneurship in adulthood (Zhang & Ilies, 2010). Chi et al. (2016) have also demonstrated that early life environments and dopamine genes interact to influence later job changes. Findings indicate that in gene X environment interaction studies, education, family and social environment as well as socioeconomic status interacted with genetic factors to influence various management-related phenotypes, including entrepreneurship (Quaye, Nicolaou, Shane & Harris, 2012a), job changes (Chi et al., 2016) and leadership (Zhang & Ilies, 2010; Zhang et al., 2009a).

In physiology, research has indicated, for instance, that the interaction between chronic pain and perceived organizational support influences citizenship behavior, work intensity and effectiveness as well as task performance (Byrne & Hochwarter, 2006). Specifically, higher levels of perceived organizational support decreased the adverse influences of chronic pain on occupational performance.

4. Biology X Environment correlation

Researchers have suggested that biology may play a role in people selecting particular environments that in turn influence their behavior. This implies that the environment that people face is partly endogenously influenced by their biology. In genetics, this mechanism is called gene X environment correlation (Nicolaou & Shane, 2009). There are three main types of gene X environment correlations: passive, evocative and active (Plomin et al., 2012; Shane & Nicolaou, 2015a). A passive gene X environment correlation occurs when people are exposed to inherited environments that are compatible with their genetic makeup. This correlation may lead to an association between genetic and environmental factors which in turn influence various organizational phenotypes. For example, a person with "leadership genes" would be more likely to have parents who would provide both the genes and an environment that is supportive of leadership.

An evocative gene X environment correlation suggests that people may evoke reactions from other people on the basis of their genetic tendencies. For instance, people with genes that predispose them to leadership may evoke more positive reactions from people looking for others to lead various projects and organizations.

An active gene X environment correlation demonstrates that people may select or create environments that are compatible with their genetic makeup. For example, a person

with genes that predispose them to leadership may engage in situations where leadership is required, and develop leadership capabilities through acting as a leader.

Although researchers have explained that genetic and environmental factors may correlate to influence management (Arvey et al., 2016; Lykken, Bouchard, McGue & Tellegen, 1993; Nicolaou & Shane, 2009; Shane & Nicolaou, 2015a), only one study has found evidence for this mechanism (see table S-4 in online appendix). Specifically, Li et al. (2016a) have suggested that, over time, individuals are gravitated to jobs with specific environmental conditions to satisfy their genetic makeup.

In physiology, current evidence suggests that environmental factors, particularly job demands and job controls, play a mediating role in the association between individuals' physiological well-being (i.e. cortisol and cortisone hormone levels as well as cardiovascular problems) and leadership role occupancy (Li & Xie, 2013).

5. Interactions within Biological strands

The existing literature has also revealed evidence for interactions within biological strands, such as interactions between genes - a mechanism that researchers have labeled gene X gene interactions (Polderman et al., 2015), interactions between hormones – a mechanism labeled hormone X hormone interactions, and interactions between different brain regions. Research, for instance, has suggested that genes may jointly interact to influence management outcomes such as job satisfaction (Song et al., 2011). Researchers have also shown that cortisol and testosterone jointly interact to influence attained status in male executives (Sherman et al., 2016). In another study, Mehta and Josephs (2010) indicated that high levels of cortisol diminish the influence of testosterone on dominance. Moreover, neuroscience studies have also found that the interactions between the orbitofrontal cortex, the anterior cingulate cortex, and the locus coeruleus may modulate attention, which

influences exploration and exploitation decisions (Aston-Jones & Cohen, 2005; Laureiro-Martínez, Brusoni & Zollo, 2010).

6. Interactions between Biological strands

Different biological strands may also interact to influence management. Epigenetics demonstrates that biological and environmental stimuli may modify genes transcription. Studies have suggested that biological factors, such as hormones and neuroscience, may play a key interactive role in the modification of such genes (Caspi & Moffitt, 2006; Zhang & Meaney, 2010). However, we did not find any studies examining epigenetics in management.

Frank et al. (2009) have also suggested that the dopaminergic genes interact with the prefrontal cortex region of the brain to influence individuals' exploration and exploitation decisions. This relationship is mediated in two steps, first, by the interaction between the stratium region of the brain and reinforcement learning environments and, then, the dopamine hormone which influences exploration and exploitation. Thus, different mechanisms can jointly shape managerial behavior.

DISCUSSION AND IMPLICATIONS

Our organizing framework (figure 1) highlights the three strands of the biological perspective, shows the constituents of each, and maps the distribution of studies across them. Importantly, this review uncovers several mechanisms (figure 2) through which biology influences management. However, we argue that, to fulfill the potential of this perspective, all aspects must be integrated, something that has not happened to date. As we mentioned, the mechanisms explaining these relationships suggest that biological factors are not mutually exclusive and the mechanisms that govern the influence of one biological factor on management involve other biological factors.

Our review reveals that genetic factors explain more than one-third of the variance in many phenotypes, such as work values (Arvey, McCall, Bouchard, Taubman & Cavanaugh, 1994), creativity (Shane & Nicolaou, 2015b), job switching (McCall, Cavanaugh, Arvey & Taubman, 1997), transactional leadership (Johnson et al., 1998) and the propensity to engage in entrepreneurship (Nicolaou et al., 2008a). The genetic influences are both polygenic and pleiotropic, and the influence of a single genetic polymorphism is very small, reflecting the complex architecture of management phenotypes.

To date, physiological variables have played a peripheral role in the study of management (Zhang & Zyphur, 2015) but as Heaphy and Dutton (2008) argue, management research that does not take into account the role of physiology is incomplete. However, relatively few physiological characteristics and relatively few outcomes have been explored. In addition, the majority of studies in the hormones stream of research have focused on the effects of just one hormone, testosterone, with relatively fewer studies examining the effects of cortisol. Furthermore, there have been no studies examining the effects of oxytocin, serotonin, or dopamine.

A small literature now shows that brain function is associated with managerial behavior, as demonstrated by neuroscience studies in leadership, decision-making, entrepreneurship, and work stress. Studies have also examined the influence of ADHD and dyslexia on managerial outcomes. While relatively few aspects of management have been explored empirically, with leadership being the most prevalent, this literature has provided a "theoretical basis as to the choice of neurological variables that one might incorporate" in the study of neuroscience and management (Waldman et al., 2016b: 9.13).

The lack of research in this area is puzzling. We are all biological creatures and our biology affects all aspects of our behavior, including our work. By ignoring our biology,

management researchers are missing an important part of the explanation for managerial behavior.

The biological perspective has several theoretical implications. It improves our understanding of how biological factors moderate the influence of environmental factors in influencing work outcomes. It extends existing theories in organizational behavior by identifying how psychological traits and attitudes mediate the influence of biology. It also enhances our understanding of the antecedents of environmental factors, by showing that these are often biologically influenced, a finding called nature of nurture (Arvey et al., 2016; Plomin & Bergeman, 1991).

The biological perspective has some important implications for the practice of management. The biological perspective may affect career coaching and may help organizations provide individualized practices suited to the different distinctive abilities of their personnel (Arvey et al., 2016; Lawler, 1974; Rousseau, 2005). For instance, drawing on the finding that ADHD has a positive influence on entrepreneurial activities, organizations may encourage people with ADHD to pursue such careers.

The biological perspective may also deliver insights to policy makers by revealing the environmental factors moderating the biological influences on management. Understanding those factors would allow policy makers to know how to reinforce positive interactions and minimize negative ones.

In addition, by knowing the architecture of physiological conditions, organizations may change various job features to diminish any negative influences at work. For instance, because high workloads increase cardiovascular risks in employees, it might be valuable to identify the job features that attenuate the negative influences of high workloads (Ilies, Dimotakis & De Pater, 2010). This line of research would also have the potential to answer various enquiries in the occupational health and safety literature, such as “the links between

occupational health and safety and human resource strategies" (Zanko & Dawson, 2012: 340).

The biological perspective may also provide organizations with strategies to maximize corporate venturing activities. For example, researchers found that genetic factors account for 82 percent of the covariance between creativity and the tendency towards entrepreneurship (Shane & Nicolaou, 2015b) and 46% of the covariance between sensation seeking and the tendency to engage in entrepreneurship (Nicolaou et al., 2008b). As environmental factors account for a greater part of the covariance between sensation seeking and entrepreneurship than between creativity and entrepreneurship (e.g. 54% and 18% respectively), efforts to influence sensation seeking would be more effective than efforts to influence creativity in affecting entrepreneurship.

However, several challenges face this area of research. These include (1) the challenges of conducting interdisciplinary research (Bromham, Dinnage & Hua, 2016), (2) the difficulties of generating heritability estimates in the presence of gene-environment interactions and correlations (Arvey et al., 2016), (3) small effect sizes, (4) endogeneity issues, (5) experimental conditions in neuroscientific experiments, and (6) issues of reverse inference in fMRI studies (Poldrack, 2006). Scholars will need to address these issues in their study designs to move our collective understanding of the biological influences on management forward.

FUTURE RESEARCH DIRECTIONS

Our review suggests several areas for future research. First, more explanatory factors and more outcome variables should be examined empirically. The review shows that research in this area is characterized by being highly conceptual with limited empirical evidence. It is time to further this area of research by conducting more empirical studies.

Second, it is unlikely that much managerial behavior is explained solely by human biology. Because most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management. Although research has suggested plausible mechanisms through which these factors jointly influence management, we have little empirical evidence of those interactions.

Third, biological factors are not mutually exclusive and may jointly interact to influence management behavior. Future research should explore those interactions. For example, future research should consider how hormones mediate genetic predispositions and in turn trigger physiological effects to influence management. Similarly, studies should explore how genes interact with environmental factors, such as occupational threat, stimulating the hypothalamic pituitary adrenal axis to trigger the stress hormone "cortisol," which, in turn, may affect managerial outcomes, such as leadership. Finally, future genetics work should draw from neuroscience research for the formulation of gene-environment interaction hypotheses (Caspi & Moffitt, 2006).

Fourth, additional research on the psychological factors and attitudes that mediate the relationship between biology (genetics, physiology and neuroscience) and management is encouraged. Additional mediators can advance our understanding of the theoretical mechanisms through which the influence of biological factors on management is manifested.

Fifth, researchers should incorporate epigenetics into the study of the biological perspective. Numerous epigenetics mechanisms have been uncovered over the past decade, such as DNA methylation, DNA hydroxymethylation, and histone modifications like acetylation, phosphorylation, and sumoylation (Zhang & Meaney, 2010). These mechanisms reveal that environmental factors may alter people's genetic, physiological and neurological factors.

Sixth, researchers should think about the effects of biological factors more dynamically. In this domain, few longitudinal studies have been conducted. Longitudinal studies would reveal how biological influences can change over time. For instance, genetic influences on leadership could change with age, given evidence of age-related changes in the heritability of job satisfaction (Li et al., 2016b) and other behavioral measures in the sciences (Bergen, Gardner & Kendler, 2007).

Additional research pertaining to each area is also needed. For example, in genetics, we encourage further research using bivariate and multivariate genetic techniques that explore shared genetic influences between management-related phenotypes. Genome-wide association studies using very large samples are also needed to advance molecular genetic research in management. Nuclear twin family models, which are an improvement over the classical twin model as they incorporate more family information about twins, their parents, and siblings, are also encouraged, as they can provide more accurate parameters for the decomposition of genetic and environmental influences (Zyphur, Zhang, Barsky & Li, 2013). Studies identifying gene-environment correlations in organizational settings are also needed.

In physiology, research is needed to empirically examine the influence of oxytocin, dopamine, serotonin, and melatonin, as studies in management have only examined empirically the role of testosterone and cortisol. Additional work is also needed to examine how hormones interact with each other, such as the dual hormone hypothesis that emphasized the combined effects of testosterone and cortisol in regulating dominance (Mehta and Josephs, 2010). Future work could also examine physiological responses at the group level, while additional research is required to examine how organizational interventions can moderate the influence of physiological processes on managerial outcomes.

In neuroscience, future research should also incorporate neuroscience techniques into the study of teams. As management outcomes are highly dependent on interactions between

individuals, researchers are encouraged to use neuroscience techniques, such as qEEG, to examine interactions between employees, such as interpersonal conflicts and negative/positive affect (Waldman et al., 2016b).

Further research pertaining to each management area including entrepreneurship and organizational behavior is also urged. For instance, in entrepreneurship, work employing a biological perspective is needed to examine topics such as entrepreneurial biases (Zhang & Cueto, 2017: 2), fear of failure (Cacciotti, Hayton, Mitchell & Giazitzoglu, 2016), and entrepreneurs' thinking styles, skills and goal commitment (Bönte et al., 2015). In organizational behavior, additional research is needed on the biological underpinnings of human resource management and work design (Arvey et al., 2016) including GWAS and fMRI studies.

CONCLUSION

Much progress has been made in research on the biological perspective over the past years that has enriched our understanding of various organizational phenomena. Yet, many gaps about the underpinnings linking biology to management remain. This review has systematically provided a summary of what has been achieved in this area of research and has offered a number of directions to take the field forward. We hope that this work may inspire additional research in this area to further our understanding of management.

REFERENCES

Agerstrom, J., & Rooth, D. O. 2011. The role of automatic obesity stereotypes in real hiring discrimination. *Journal of Applied Psychology,* 96(4): 790-805.

Alrajih, S., & Ward, J. 2014. Increased facial width-to-height ratio and perceived dominance in the faces of the uk's leading business leaders. *British Journal of Psychology,* 105(2): 153-161.

Arora, P., Haynie, J. M., & Laurence, G. A. 2013. Counterfactual thinking and entrepreneurial self- efficacy: The moderating role of self- esteem and dispositional affect. *Entrepreneurship Theory and Practice,* 37(2): 359-385.

Arvey, R., Wang, N., Song, Z., & Li, W. 2014. The biology of leadership. In D. V. Day (Ed.), *The oxford handbook of leadership and organizations*: Oxford University Press.

Arvey, R. D., Bouchard, T. J., Segal, N. L., & Abraham, L. M. 1989. Job satisfaction: Environmental and genetic components. *Journal of Applied Psychology,* 74(2): 187-192.

Arvey, R. D., Li, W.-D., & Wang, N. 2016. Genetics and organizational behavior. *Annual Review of Organizational Psychology and Organizational Behavior,* 3(1): 167-190.

Arvey, R. D., McCall, B. P., Bouchard, T. J., Taubman, P., & Cavanaugh, M. A. 1994. Genetic influences on job satisfaction and work values. *Personality and Individual Differences,* 17(1): 21-33.

Arvey, R. D., Rotundo, M., Johnson, W., Zhang, Z., & McGue, M. 2006. The determinants of leadership role occupancy: Genetic and personality factors. *The Leadership Quarterly,* 17(1): 1-20.

Arvey, R. D., Zhang, Z., Avolio, B. J., & Krueger, R. F. 2007. Developmental and genetic determinants of leadership role occupancy among women. *Journal of Applied Psychology,* 92(3): 693-706.

Aston-Jones, G., & Cohen, J. D. 2005. An integrative theory of locus coeruleus-norepinephrine function: Adaptive gain and optimal performance. *Annu. Rev. Neurosci.,* 28: 403-450.

Avila, V. L. 1995. *Biology: Investigating life on earth*: Jones and Bartlett.

Baron, R. A., Markman, G. D., & Bollinger, M. 2006. Exporting social psychology: Effects of attractiveness on perceptions of entrepreneurs, their ideas for new products, and their financial success. *Journal of Applied Social Psychology,* 36(2): 467-492.

Becker, W. J., Cropanzano, R., & Sanfey, A. G. 2011. Organizational neuroscience: Taking organizational theory inside the neural black box. *Journal of Management,* 37(4): 933-961.

Becker, W. J., Volk, S., & Ward, M. K. 2015. Leveraging neuroscience for smarter approaches to workplace intelligence. *Human Resource Management Review,* 25(1): 56-67.

Belsky, D. W., Moffitt, T. E., Corcoran, D. L., Domingue, B., Harrington, H., Hogan, S., Houts, R., Ramrakha, S., Sugden, K., & Williams, B. S. 2016. The genetics of success: How single-nucleotide polymorphisms associated with educational attainment relate to life-course development. *Psychological Science,* 27(7): 957-972.

Bendahan, S., Zehnder, C., Pralong, F. P., & Antonakis, J. 2015. Leader corruption depends on power and testosterone. *The Leadership Quarterly,* 26(2): 101-122.

Bergen, S. E., Gardner, C. O., & Kendler, K. S. 2007. Age-related changes in heritability of behavioral phenotypes over adolescence and young adulthood: A meta-analysis. *Twin Res Hum Genet,* 10(3): 423-433.

Betsworth, D. G., Bouchard, J. T. J., Cooper, C. R., Grotevant, H. D., Hansen, J.-I. C., Scarr, S., & Weinberg, R. A. 1994. Genetic and environmental influences on vocational interests assessed using adoptive and biological families and twins reared apart and together. *Journal of Vocational Behavior,* 44(3): 263-278.

Bönte, W., Procher, V. D., & Urbig, D. 2015. Biology and selection into entrepreneurship-the relevance of prenatal testosterone exposure. *Entrepreneurship Theory and Practice,* 40(5): 1121-1148.

Boyatzis, R. E., Passarelli, A. M., Koenig, K., Lowe, M., Mathew, B., Stoller, J. K., & Phillips, M. 2012. Examination of the neural substrates activated in memories of experiences with resonant and dissonant leaders. *The Leadership Quarterly,* 23(2): 259-272.

Bromham, L., Dinnage, R., & Hua, X. 2016. Interdisciplinary research has consistently lower funding success. *Nature,* 534(7609): 684-687.

Butler, M. J., & Senior, C. 2007. Toward an organizational cognitive neuroscience. *Annals of the New York Academy of Sciences,* 1118: 1-17.

Butler, M. J. R., O'Broin, H. L. R., Lee, N., & Senior, C. 2016. How organizational cognitive neuroscience can deepen understanding of managerial decision-making: A review of the recent literature and future directions. *International Journal of Management Reviews,* 18(4): 542-559.

Byrne, Z. S., & Hochwarter, W. A. 2006. I get by with a little help from my friends: The interaction of chronic pain and organizational support on performance. *Journal of Occupational Health Psychology,* 11(3): 215-227.

Cacciotti, G., Hayton, J. C., Mitchell, J. R., & Giazitzoglu, A. 2016. A reconceptualization of fear of failure in entrepreneurship. *Journal of Business Venturing,* 31(3): 302-325.

Carter, H. D. 1932. Twin similarities in occupational interests. *Journal of Educational Psychology,* 23(9): 641-655.

Caspi, A., & Moffitt, T. E. 2006. Gene–environment interactions in psychiatry: Joining forces with neuroscience. *Nature Reviews Neuroscience,* 7(7): 583-590.

Cawley, J. 2004. The impact of obesity on wages. *The Journal of Human Resources,* 39(2): 451-474.

Cesarini, D., Johannesson, M., Magnusson, P. K. E., & Wallace, B. 2012. The behavioral genetics of behavioral anomalies. *Management Science,* 58(1): 21-34.

Chaturvedi, S., Arvey, R. D., Zhang, Z., & Christoforou, P. T. 2011. Genetic underpinnings of transformational leadership: The mediating role of dispositional hope. *Journal of Leadership & Organizational Studies,* 18(4): 469-479.

Chaturvedi, S., Zyphur, M. J., Arvey, R. D., Avolio, B. J., & Larsson, G. 2012. The heritability of emergent leadership: Age and gender as moderating factors. *The Leadership Quarterly,* 23(2): 219-232.

Chi, W., Li, W. D., Wang, N., & Song, Z. 2016. Can genes play a role in explaining frequent job changes? An examination of gene-environment interaction from human capital theory. *Journal of Applied Psychology,* 101(7): 1030-1044.

Christian, M. S., Eisenkraft, N., & Kapadia, C. 2014. Dynamic associations among somatic complaints, human energy, and discretionary behaviors experiences with pain fluctuations at work. *Administrative Science Quarterly*: 0001839214553655.

de Holan, P. M. 2013. It's all in your head: Why we need neuroentrepreneurship. *Journal of Management Inquiry,* 23(1): 93-97.

Diebig, M., Bormann, K. C., & Rowold, J. 2016. A double-edged sword: Relationship between full-range leadership behaviors and followers' hair cortisol level. *The Leadership Quarterly,* 27(4): 684-696.

Doll, L. M., Hill, A. K., Rotella, M. A., Cardenas, R. A., Welling, L. L., Wheatley, J. R., & Puts, D. A. 2014. How well do men's faces and voices index mate quality and dominance? *Human Nature,* 25(2): 200-212.

Dulebohn, J. H., Davison, R. B., Lee, S. A., Conlon, D. E., McNamara, G., & Sarinopoulos, I. C. 2016. Gender differences in justice evaluations: Evidence from fmri. *Journal of Applied Psychology,* 101(2): 151.

Frank, M. J., Doll, B. B., Oas-Terpstra, J., & Moreno, F. 2009. Prefrontal and striatal dopaminergic genes predict individual differences in exploration and exploitation. *Nature Neuroscience,* 12(8): 1062-1068.

Ganster, D. C., Fox, M. L., & Dwyer, D. J. 2001. Explaining employees' health care costs: A prospective examination of stressful job demands, personal control, and physiological reactivity. *Journal of Applied Psychology,* 86(5): 954-964.

Ganster, D. C., & Rosen, C. C. 2013. Work stress and employee health: A multidisciplinary review. *Journal of Management,* 39(5): 1085-1122.

Gielen, A. C., Holmes, J., & Myers, C. 2016. Prenatal testosterone and the earnings of men and women. *Journal of Human Resources,* 51(1): 30-61.

Greene, F. J., Han, L., Martin, S., Zhang, S., & Wittert, G. 2014. Testosterone is associated with self-employment among australian men. *Economics and Human Biology,* 13: 76-84.

Hahn, E., Gottschling, J., König, C. J., & Spinath, F. M. 2016. The heritability of job satisfaction reconsidered: Only unique environmental influences beyond personality. *Journal of Business and Psychology,* 31(2): 217-231.

Hannah, S. T., Balthazard, P. A., Waldman, D. A., Jennings, P. L., & Thatcher, R. W. 2013. The psychological and neurological bases of leader self-complexity and effects on adaptive decision-making. *Journal of Applied Psychology,* 98(3): 393-411.

Heaphy, E. D., & Dutton, J. E. 2008. Positive social interactions and the human body at work: Linking organizations and physiology. *Academy of Management Review,* 33(1): 137-162.

Ilies, R., Dimotakis, N., & De Pater, I. E. 2010. Psychological and physiological reactions to high workloads: Implications for well-being. *Personnel Psychology,* 63(2): 407-436.

Ilies, R., Dimotakis, N., & Watson, D. 2010. Mood, blood pressure, and heart rate at work: An experience-sampling study. *Journal of Occupational Health Psychology,* 15(2): 120-130.

Ilies, R., Gerhardt, M. W., & Le, H. 2004. Individual differences in leadership emergence: Integrating meta-analytic findings and behavioral genetics estimates. *International Journal of Selection and Assessment,* 12(3): 207-219.

Ilies, R., & Judge, T. A. 2003. On the heritability of job satisfaction: The mediating role of personality. *Journal of Applied Psychology,* 88(4): 750-759.

Jack, A. I., Boyatzis, R. E., Khawaja, M. S., Passarelli, A. M., & Leckie, R. L. 2013. Visioning in the brain: An fmri study of inspirational coaching and mentoring. *Social Neuroscience,* 8(4): 369-384.

Johnson, A. M., Vernon, P. A., McCarthy, J. M., Molson, M., Harris, J. A., & Jang, K. L. 1998. Nature vs nurture: Are leaders born or made? A behavior genetic investigation of leadership style. *Twin Research,* 1(4): 216-223.

Judge, T. A., & Bono, J. E. 2001. Relationship of core self-evaluations traits—self-esteem, generalized self-efficacy, locus of control, and emotional stability—with job satisfaction and job performance: A meta-analysis. *Journal of Applied Psychology,* 86(1): 80.

Judge, T. A., Ilies, R., & Zhang, Z. 2012. Genetic influences on core self-evaluations, job satisfaction, and work stress: A behavioral genetics mediated model. *Organizational Behavior and Human Decision Processes,* 117(1): 208-220.

Karlson, B., Eek, F., Hansen, Å. M., Garde, A. H., & Ørbaek, P. 2011. Cortisol variability and self-reports in the measurement of work-related stress. *Stress and Health,* 27(2): e11-e24.

Kawasaki, S., Nishimura, Y., Takizawa, R., Koike, S., Kinoshita, A., Satomura, Y., Sakakibara, E., Sakurada, H., Yamagishi, M., Nishimura, F., Yoshikawa, A., Inai, A., Nishioka, M., Eriguchi, Y., Kakiuchi, C., Araki, T., Kan, C., Umeda, M., Shimazu, A., Hashimoto, H., Kawakami, N., & Kasai, K. 2015. Using social epidemiology and

neuroscience to explore the relationship between job stress and frontotemporal cortex activity among workers. *Society for Neuroscience,* 10(3): 230-242.

Klofstad, C. A., Anderson, R. C., & Nowicki, S. 2015. Perceptions of competence, strength, and age influence voters to select leaders with lower-pitched voices. *PLoS One,* 10(8): e0133779.

Klofstad, C. A., Anderson, R. C., & Peters, S. 2012. Sounds like a winner: Voice pitch influences perception of leadership capacity in both men and women. *Proceedings of the Royal Society B,* 279(1738): 2698-2704.

Klofstad, C. A., Nowicki, S., & Anderson, R. C. 2016. How voice pitch influences our choice of leaders. *American Scientist*.

Koellinger, P. D., van der Loos, M. J. H. M., Groenen, P. J. F., Thurik, A. R., Rivadeneira, F., van Rooij, F. J. A., Uitterlinden, A. G., & Hofman, A. 2010. Genome-wide association studies in economics and entrepreneurship research: Promises and limitations. *Small Business Economics,* 35(1): 1-18.

Kong, D. T. 2014. An economic–genetic theory of corporate corruption across cultures: An interactive effect of wealth and the 5httlpr-ss/sl frequency on corporate corruption mediated by cultural endorsement of self-protective leadership. *Personality and Individual Differences,* 63: 106-111.

Laureiro-Martínez, D., Brusoni, S., Canessa, N., & Zollo, M. 2015. Understanding the exploration-exploitation dilemma: An fmri study of attention control and decision-making performance. *Strategic Management Journal,* 36(3): 319-338.

Laureiro-Martínez, D., Brusoni, S., & Zollo, M. 2010. The neuroscientific foundations of the exploration−exploitation dilemma. *Journal of Neuroscience, Psychology, and Economics,* 3(2): 95-115.

Laureiro-Martinez, D., Canessa, N., Brusoni, S., Zollo, M., Hare, T., Alemanno, F., & Cappa, S. F. 2014. Frontopolar cortex and decision-making efficiency: Comparing brain activity of experts with different professional background during an exploration-exploitation task. *Frontiers in Human Neuroscience,* 7: 927.

Lawler, E. E. 1974. The individualized organization: Problems and promise. *California Management Review,* 17(2): 31-39.

Li, W.-D., Arvey, R. D., Zhang, Z., & Song, Z. 2012. Do leadership role occupancy and transformational leadership share the same genetic and environmental influences? *The Leadership Quarterly*, 23(2): 233-243.

Li, W.-D., Wang, N., Arvey, R. D., Soong, R., Saw, S. M., & Song, Z. 2015. A mixed blessing? Dual mediating mechanisms in the relationship between dopamine transporter gene dat1 and leadership role occupancy. *The Leadership Quarterly,* 26(5): 671-686.

Li, W.-D., & Xie, J. L. 2013. Mixed blessing: Toward a dual pathway model of leadership role occupancy and leaders' well-being. *Academy of Management Proceedings*: 12787: Academy of Management.

Li, W.-D., Zhang, Z., Song, Z., & Arvey, R. D. 2016a. It is also in our nature: Genetic influences on work characteristics and in explaining their relationships with well-being. *Journal of Organizational Behavior,* 37(6): 868-888.

Li, W. 2011. Proactive personality and work success: Disentangling genetic and environmental influences. *Annual Academy of Management Meeting*. San Antonio, Texas.

Li, W. D., Stanek, K. C., Zhang, Z., Ones, D. S., & McGue, M. 2016b. Are genetic and environmental influences on job satisfaction stable over time? A three-wave longitudinal twin study. *Journal of Applied Psychology*.

Lindquist, M. J., Sol, J., & Van Praag, M. 2015. Why do entrepreneurial parents have entrepreneurial children? *Journal of Labor Economics,* 33(2): 269-296.

Little, A. C. 2014. Facial appearance and leader choice in different contexts: Evidence for task contingent selection based on implicit and learned face-behaviour/face-ability associations. *The Leadership Quarterly,* 25(5): 865-874.

Little, A. C., Burriss, R. P., Jones, B. C., & Roberts, S. C. 2007. Facial appearance affects voting decisions. *Evolution and Human Behavior,* 28(1): 18-27.

Logan, J. 2009. Dyslexic entrepreneurs: The incidence; their coping strategies and their business skills. *Dyslexia,* 15(4): 328-346.

Lundberg, U., & Frankenhaeuser, M. 1999. Stress and workload of men and women in high-ranking positions. *Journal of Occupational Health Psychology,* 4(2): 142-151.

Lykken, D. T., Bouchard, T. J., Jr., McGue, M., & Tellegen, A. 1993. Heritability of interests: A twin study. *Journal of Applied Psychology,* 78(4): 649-661.

Manville, C., Akremi, A. E., Niezborala, M., & Mignonac, K. 2016. Injustice hurts, literally: The role of sleep and emotional exhaustion in the relationship between organizational justice and musculoskeletal disorders. *Human Relations,* 69(6): 1315-1339.

Matteson, M. T., & Ivancevich, J. M. 1979. Organizational stressors and heart disease: A research model. *Academy of Management Review,* 4(3): 347-357.

McCall, B. P., Cavanaugh, M. A., Arvey, R. D., & Taubman, P. 1997. Genetic influences on job and occupational switching. *Journal of Vocational Behavior,* 50(1): 60-77.

Mehta, P. H., & Josephs, R. A. 2010. Testosterone and cortisol jointly regulate dominance: Evidence for a dual-hormone hypothesis. *Hormone and Behavior,* 58(5): 898-906.

Melin, B., Lundberg, U., Soderlund, J., & Granqvist, M. 1999. Psychological and physiological stress reactions of male and female assembly workers: A comparison between two different forms of work organization. *Journal of Organizational Behavior,* 20(1): 47-61.

Molenberghs, P., Prochilo, G., Steffens, N. K., Zacher, H., & Haslam, S. A. 2015. The neuroscience of inspirational leadership: The importance of collective-oriented language and shared group membership. *Journal of Management*.

Munafò, M. R. 2006. Candidate gene studies in the 21st century: Meta-analysis, mediation, moderation. *Genes, Brain and Behavior,* 5(S1): 3-8.

Narayanan, J., & Prasad, S. 2015. Neurobiological systems: Implications for organizational behavior. In S. M. Colarelli and R. D. Arvey (Eds.), *The biological foundations of organizational behavior*: University of Chicago Press.

Nicolaou, N., Patel, P. C., & Wolfe, M. T. in press. Testosterone and tendency to engage in self-employment. *Management Science*.

Nicolaou, N., & Shane, S. 2009. Can genetic factors influence the likelihood of engaging in entrepreneurial activity? *Journal of Business Venturing,* 24(1): 1-22.

Nicolaou, N., & Shane, S. 2013. Biology, neuroscience, and entrepreneurship. *Journal of Management Inquiry,* 23(1): 98-100.

Nicolaou, N., Shane, S., Adi, G., Mangino, M., & Harris, J. 2011. A polymorphism associated with entrepreneurship: Evidence from dopamine receptor candidate genes. *Small Business Economics,* 36(2): 151-155.

Nicolaou, N., Shane, S., Cherkas, L., Hunkin, J., & Spector, T. D. 2008a. Is the tendency to engage in entrepreneurship genetic? *Management Science,* 54(1): 167-179.

Nicolaou, N., Shane, S., Cherkas, L., & Spector, T. D. 2008b. The influence of sensation seeking in the heritability of entrepreneurship. *Strategic Entrepreneurship Journal,* 2(1): 7-21.

Nicolaou, N., Shane, S., Cherkas, L., & Spector, T. D. 2009. Opportunity recognition and the tendency to be an entrepreneur: A bivariate genetics perspective. *Organizational Behavior and Human Decision Processes,* 110(2): 108-117.

Olivola, C. Y., Eubanks, D. L., & Lovelace, J. B. 2014. The many (distinctive) faces of leadership: Inferring leadership domain from facial appearance. *The Leadership Quarterly,* 25(5): 817-834.

Plomin, R., & Bergeman, C. S. 1991. The nature of nurture: Genetic influence on "environmental" measures. *Behavioral and Brain Sciences,* 14(03): 373-386.

Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. M. 2012. *Behavioral genetics*: Worth Publishers.

Polderman, T. J. C., Benyamin, B., de Leeuw, C. A., Sullivan, P. F., van Bochoven, A., Visscher, P. M., & Posthuma, D. 2015. Meta-analysis of the heritability of human traits based on fifty years of twin studies. *Nature Genetics,* 47(7): 702-709.

Poldrack, R. A. 2006. Can cognitive processes be inferred from neuroimaging data? *Trends in cognitive sciences,* 10(2): 59-63.

Quaye, L., Nicolaou, N., Shane, S., & Harris, J. 2012a. A study of gene-environment interactions in entrepreneurship. *Entrepreneurship Research Journal,* 2(2).

Quaye, L., Nicolaou, N., Shane, S., & Mangino, M. 2012b. A discovery genome-wide association study of entrepreneurship. *International Journal of Developmental Science,* 6: 127–135.

Raven, P., Johnson, G., Mason, K., Losos, J., & Singer, S. 2013. *Biology* (10 ed.): McGraw-Hill Higher Education.

Re, D. E., DeBruine, L. M., Jones, B. C., & Perrett, D. I. 2013. Facial cues to perceived height influence leadership choices in simulated war and peace contexts. *Evolutionary Psychology,* 11(1).

Re, D. E., Dzhelyova, M., Holzleitner, I. J., Tigue, C. C., Feinberg, D. R., & Perrett, D. I. 2012. Apparent height and body mass index influence perceived leadership ability in three-dimensional faces. *Perception,* 41(12): 1477-1485.

Re, D. E., & Perrett, D. I. 2014. The effects of facial adiposity on attractiveness and perceived leadership ability. *Quarterly journal of experimental psychology (Hove),* 67(4): 676-686.

Ronay, R., & Carney, D. R. 2013. Testosterone's negative relationship with empathic accuracy and perceived leadership ability. *Social Psychological and Personality Science,* 4(1): 92-99.

Rousseau, D. 2005. I-deals: Idiosyncratic deals employees negotiate for themselves. *New York, NY: ME Sharpe*.

Rowe, D. C. 2003. Assessing genotype-environment interactions and correlations in the postgenomic era. In R. Plomin, J. C. DeFries, I. W. Craig and P. McGuffin (Eds.), *Behavioral genetics in the postgenomic era*: 71–99. Washington: American Psychological Association.

Saphire-Bernstein, S., Way, B. M., Kim, H. S., Sherman, D. K., & Taylor, S. E. 2011. Oxytocin receptor gene (oxtr) is related to psychological resources. *Proceedings of the National Academy of Sciences,* 108(37): 15118-15122.

Scarr, S., & Weinberg, R. A. 1994. Educational and occupational achievements of brothers and sisters in adoptive and biologically related families. *Behav Genet,* 24(4): 301-325.

Schaubroeck, J., Ganster, D. C., & Kemmerer, B. E. 1994. Job complexity, "type a" behavior, and cardiovascular disorder: A prospective study. *Academy of Management Journal,* 37(2): 426-439.

Schaubroeck, J., & Merritt, D. E. 1997. Divergent effects of job control on coping with work stressors: The key role of self-efficacy. *Academy of Management Journal,* 40(3): 738-754.

Schermer, J. A., Johnson, A. M., Jang, K. L., & Vernon, P. A. 2015. Phenotypic, genetic, and environmental relationships between self-reported talents and measured intelligence. *Twin Research and Human Genetics,* 18(1): 36-42.

Shane, S. 2009. Introduction to the focused issue on the biological basis of business. *Organizational Behavior and Human Decision Processes,* 110(2): 67-69.

Shane, S., & Nicolaou, N. 2015a. The biological basis of entrepreneurship. In S. M. Colarelli and R. D. Arvey (Eds.), *The biological foundations of organizational behavior*: University of Chicago Press.

Shane, S., & Nicolaou, N. 2015b. Creative personality, opportunity recognition and the tendency to start businesses: A study of their genetic predispositions. *Journal of Business Venturing,* 30(3): 407-419.

Shane, S., Nicolaou, N., Cherkas, L., & Spector, T. D. 2010a. Do openness to experience and recognizing opportunities have the same genetic source? *Human Resource Management,* 49(2): 291-303.

Shane, S., Nicolaou, N., Cherkas, L., & Spector, T. D. 2010b. Genetics, the big five, and the tendency to be self-employed. *Journal of Applied Psychology,* 95(6): 1154-1162.

Sherman, G. D., Lee, J. J., Cuddy, A. J., Renshon, J., Oveis, C., Gross, J. J., & Lerner, J. S. 2012. Leadership is associated with lower levels of stress. *Proceedings of the National Academy of Sciences (PNAS),* 109(44): 17903-17907.

Sherman, G. D., Lerner, J. S., Josephs, R. A., Renshon, J., & Gross, J. J. 2016. The interaction of testosterone and cortisol is associated with attained status in male executives. *Journal of Personality and Social Psychology,* 110(6): 921-929.

Silverthorn, D. U. 2001. *Human physiology: An integrated approach*: Prentice Hall.

Song, Z., Li, W., & Arvey, R. D. 2011. Associations between dopamine and serotonin genes and job satisfaction: Preliminary evidence from the add health study. *Journal of Applied Psychology,* 96(6): 1223-1233.

Song, Z., Li, W., & Wang, N. 2015. Progress in molecular genetics and its potential implications in organizational behavior research. In S. M. Colarelli and R. D. Arvey (Eds.), *The biological foundations of organizational behavior*: University of Chicago Press.

Steffy, B. D., & Jones, J. W. 1988. Workplace stress and indicators of coronary-disease risk. *Academy of Management Journal*, 31(3): 686-698.

Thurik, R., Khedhaouria, A., Torrès, O., & Verheul, I. 2016. Adhd symptoms and entrepreneurial orientation of small firm owners. *Applied Psychology*, 65(3): 568-586.

Trahms, C. A., Coombs, J. E., & Barrick, M. 2010. Does biology matter? : How prenatal testosterone, entrepreneur risk propensity, and entrepreneur risk perceptions influence venture performance. *Frontiers of entrepreneurship research 2010 : proceedings of the thirtieth annual Entrepreneurship Research Conference*: 217-229.

Tranfield, D., Denyer, D., & Smart, P. 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3): 207-222.

Unger, J. M., Rauch, A., Narayanan, J., Weis, S., & Frese, M. 2009. Does prenatal testosterone predict entrepreneurial success? Relationships of 2d: 4d and business success (summary). *Frontiers of Entrepreneurship Research*, 29(5): 15.

Unger, J. M., Rauch, A., Weis, S. E., & Frese, M. 2015. Biology (prenatal testosterone), psychology (achievement need) and entrepreneurial impact. *Journal of Business Venturing Insights*, 4: 1-5.

van der Loos, M. J. H. M., Koellinger, P. D., Groenen, P. J. F., & Thurik, A. R. 2010. Genome-wide association studies and the genetics of entrepreneurship. *European Journal of Epidemiology*, 25(1): 1-3.

van der Loos, M. J. H. M., Rietveld, C. A., Eklund, N., Koellinger, P. D., Rivadeneira, F., Abecasis, G. R., Ankra-Badu, G. A., Baumeister, S. E., Benjamin, D. J., Biffar, R.,

Blankenberg, S., Boomsma, D. I., Cesarini, D., Cucca, F., de Geus, E. J. C., Dedoussis, G., Deloukas, P., Dimitriou, M., Eiriksdottir, G., Eriksson, J., Gieger, C., Gudnason, V., Hohne, B., Holle, R., Hottenga, J.-J., Isaacs, A., Jarvelin, M.-R., Johannesson, M., Kaakinen, M., Kahonen, M., Kanoni, S., Laaksonen, M. A., Lahti, J., Launer, L. J., Lehtimaki, T., Loitfelder, M., Magnusson, P. K. E., Naitza, S., Oostra, B. A., Perola, M., Petrovic, K., Quaye, L., Raitakari, O., Ripatti, S., Scheet, P., Schlessinger, D., Schmidt, C. O., Schmidt, H., Schmidt, R., Senft, A., Smith, A. V., Spector, T. D., Surakka, I., Svento, R., Terracciano, A., Tikkanen, E., van Duijn, C. M., Viikari, J., Volzke, H., Wichmann, H.-E., Wild, P. S., Willems, S. M., Willemsen, G., van Rooij, F. J. A., Groenen, P. J. F., Uitterlinden, A. G., Hofman, A., & Thurik, A. R. 2013. The molecular genetic architecture of self-employment. *PLoS One,* 8(4): e60542.

Verheul, I., Block, J., Burmeister-Lamp, K., Thurik, R., Tiemeier, H., & Turturea, R. 2015. Adhd-like behavior and entrepreneurial intentions. *Small Business Economics*, 45(1): 85-101.

Verheul, I., Rietdijk, W., Block, J., Franken, I., Larsson, H., & Thurik, R. 2016. The association between attention-deficit/hyperactivity (adhd) symptoms and self-employment. *European Journal of Epidemiology,* 31(8): 793-801.

Waldman, D., Wang, D., Hannah, S., & Balthazard, P. in press. A neurological and ideological perspective of ethical leadership. *Academy of Management Journal*.

Waldman, D. A., Balthazard, P. A., & Peterson, S. J. 2011. Leadership and neuroscience: Can we revolutionize the way that inspirational leaders are identified and developed? *The Academy of Management Perspectives,* 25(1): 60-74.

Waldman, D. A., Wang, D., & Fenters, V. 2016a. The added value of neuroscience methods in organizational research. *Organizational Research Methods*: 1094428116642013.

Waldman, D. A., Ward, M., & Becker, W. J. 2016b. Neuroscience in organizational behavior. *Annual Review of Organizational Psychology and Organizational Behavior*(0).

Ward, M., Volk, S., & Becker, W. J. 2015. An overview of organizational neuroscience. *Organizational neuroscience*: 17-50.

Wernerfelt, N., Rand, D. G., Dreber, A., Montgomery, C., & Malhotra, D. K. 2012. Arginine vasopressin 1a receptor (avpr1a) rs3 repeat polymorphism associated with entrepreneurship. Available at SSRN: https://ssrn.com/abstract=2141598.

White, R. E., Thornhill, S., & Hampson, E. 2006. Entrepreneurs and evolutionary biology: The relationship between testosterone and new venture creation. *Organizational Behavior and Human Decision Processes,* 100(1): 21-34.

Wiklund, J., Patzelt, H., & Dimov, D. 2016. Entrepreneurship and psychological disorders: How adhd can be productively harnessed. *Journal of Business Venturing Insights,* 6: 14-20.

Yeo, G. S. 2011. Where next for gwas? *Brief Funct Genomics,* 10(2): 51.

Zanko, M., & Dawson, P. 2012. Occupational health and safety management in organizations: A review. *International Journal of Management Reviews,* 14(3): 328-344.

Zhang, S. X., & Cueto, J. 2017. The study of bias in entrepreneurship. *Entrepreneurship Theory and Practice,* 41(3): 419-454.

Zhang, T.-Y., & Meaney, M. J. 2010. Epigenetics and the environmental regulation of the genome and its function. *Annual Review of Psychology,* 61: 439-466.

Zhang, Z., & Ilies, R. 2010. Moderating effects of earlier family environment on genetic influences on entrepreneurship. *Symposium Presentation at the Annual Conference of the Academy of Management*. Montréal, Canada.

Zhang, Z., Ilies, R., & Arvey, R. D. 2009a. Beyond genetic explanations for leadership: The moderating role of the social environment. *Organizational Behavior and Human Decision Processes,* 110(2): 118-128.

Zhang, Z., & Zyphur, M. J. 2015. Physiological functioning and employee health in organizations. In S. M. Colarelli and R. D. Arvey (Eds.), *The biological foundations of organizational behavior*: University of Chicago Press.

Zhang, Z., Zyphur, M. J., Narayanan, J., Arvey, R. D., Chaturvedi, S., Avolio, B. J., Lichtenstein, P., & Larsson, G. 2009b. The genetic basis of entrepreneurship: Effects of gender and personality. *Organizational Behavior and Human Decision Processes,* 110(2): 93-107.

Zyphur, M. J., Li, W.-D., Zhang, Z., Arvey, R. D., & Barsky, A. P. 2015. Income, personality, and subjective financial well-being: The role of gender in their genetic and environmental relationships. *Frontiers in Psychology,* 6.

Zyphur, M. J., Zhang, Z., Barsky, A. P., & Li, W.-D. 2013. An ace in the hole: Twin family models for applied behavioral genetics research. *The Leadership Quarterly,* 24(4): 572-594.

FOOTNOTES

[1] The Association of Business School's Academic Journal Guide (ABS, 2015) provides a list of 1401 journals in different business areas.

[2] Although 'biology' and 'physiology' are sometimes used interchangeably, biology is the study of living organisms, divided into various sub-disciplines, such as anatomy, immunology, microbiology, physiology and neurology (Avila, 1995; Raven, Johnson, Mason, Losos & Singer, 2013).

[3] Sherman et al (2016) examined the association of both testosterone and cortisol with attained status in male executives.

[4] ADHD is a "neurodevelopmental disorder characterized by attention-deficit and hyperactivity" (Verheul., 2016: 793).

Table 1

Articles included in the Systematic Review (sorted by year) *

Genetics	Physiology	Neuroscience
(Carter, 1932)	(Chase, 1967)	(Hines, 1987)
(Vandenberg & Kelly, 1964)	(Ramey, 1973)	(Mannuzza, Klein, Bessler, Malloy & LaPadula, 1993)
(Vandenberg & Stafford, 1967)	(Matteson & Ivancevich, 1979)	(Carroll & Ponterotto, 1998)
(Novit, 1981)	(Purifoy & Koopmans, 1979)	(Cooper, 2000)
(Kefalas & Suojanen, 1974)	(Cann, Siegfried & Pearce, 1981)	(Kussrow, 2001)
(Arvey et al., 1989)	(Ivancevich, Matteson & Preston, 1982)	(Taylor & Walter, 2003)
(Tambs, Sundet, Magnus & Berg, 1989)	(Rose, Jenkins, Hurst, Herd & Hall, 1982)	(Reynolds, 2006)
(Cropanzano & James, 1990)	(Balick & Herd, 1987)	(Rock & Schwartz, 2006)
(Moloney, Bouchard & Segal, 1991)	(Chung & Leung, 1988)	(Bailey, 2007)
(Lykken, McGue, Tellegen & Bouchard, 1992)	(Steffy & Jones, 1988)	(Butler & Senior, 2007a)
(Bouchard, Arvey, Keller & Segal, 1992)	(Dabbs, de La Rue & Williams, 1990)	(Butler & Senior, 2007b)
(Keller, Bouchard, Arvey, Segal & Dawis, 1992)	(Dabbs, 1992)	(Dvorak & Badal, 2007)
(Lichtenstein, Pedersen & McClearn, 1992)	(Fox, Dwyer & Ganster, 1993)	(Klein & D'Esposito, 2007)
(Kupfer, 1993)	(Schaubroeck et al., 1994)	(Lee & Chamberlain, 2007)
(Lykken et al., 1993)	(Schaubroeck & Merritt, 1997)	(Goleman & Boyatzis, 2008)
(Arvey & Bouchard, 1994)	(Dabbs, Alford & Fielden, 1998)	(Gordon, 2008)
	(Lundberg & Frankenhaeuser, 1999)	(Lee, Butler & Senior, 2008)
	(Melin et al., 1999)	(Painter, Prevatt & Welles, 2008)
	(Evans & Steptoe, 2001)	(Peterson, Balthazard, Waldman & Thatcher, 2008)
	(Ganster et al., 2001)	(Ringleb & Rock, 2008)
	(Rau, Georgiades, Fredrikson, Lemne & de Faire, 2001)	(Senior, Lee & Butler, 2008a)
	(Chiu & Babcock, 2002)	(Senior, Lee & Butler, 2008b)
		(Beugré, 2009)
		(Halmøy, Fasmer, Gillberg & Haavik, 2009)
		(Kleinman, Durkin, Melkonian

(Arvey et al., 1994)
(Betsworth et al., 1994)
(Hershberger, Lichtenstein & Knox, 1994)
(Scarr & Weinberg, 1994)
(Strudler, 1994)
(McCall et al., 1997)
(Johnson et al., 1998)
(Murry, Wimbush & Dalton, 2001)
(Ilies & Judge, 2003)
(Roberts, 2003)
(Ilies et al., 2004)
(Johnson, Vernon, Harris & Jang, 2004)
(Arvey et al., 2006)
(Ilies, Arvey & Bouchard, 2006)
(Arvey et al., 2007)
(Barclay & Markel, 2007)
(Nicolaou et al., 2008a)
(Nicolaou et al., 2008b)
(Salter, 2008)
(Frank et al., 2009)
(Johnson, 2009)
(Nicolaou & Shane, 2009)
(Nicolaou et al., 2009)
(Zhang et al., 2009a)
(Zhang et al., 2009b)
(Lundberg & Hellström, 2002)
(Roehling, 2002)
(Barling, Kelloway & Iverson, 2003)
(Fannin & Dabbs, 2003)
(Hosoda, Stone-Romero & Coats, 2003)
(Cawley, 2004)
(Judge & Cable, 2004)
(Kunz-Ebrecht, Kirschbaum, Marmot & Steptoe, 2004)
(Schlotz, Hellhammer, Schulz & Stone, 2004)
(Ferris, Sinclair & Kline, 2005)
(Tunceli, Bradley, Nerenz, Williams, Pladevall & Elston Lafata, 2005)
(Baron et al., 2006)
(Byrne & Hochwarter, 2006)
(White et al., 2006)
(Little et al., 2007)
(Lovelace, Manz & Alves, 2007)
(Tomasino, 2007)
(White, Thornhill & Hampson, 2007)
(Heaphy & Dutton, 2008)
(Rystedt, Cropley, Devereux & Michalianou, 2008)
(Wirtz, Siegrist, Rimmele & Ehlert, 2008)
(Bass & Bass, 2009)
(Han, Norton & Stearns, 2009)
& Markosyan, 2009)
(Logan, 2009)
(Salvador & Folger, 2009)
(Becker & Cropanzano, 2010)
(Lafferty & Alford, 2010)
(Laureiro-Martínez et al., 2010)
(Lee, Butler & Senior, 2010)
(Rock, 2010)
(Senior, 2010)
(Becker et al., 2011)
(Boyatzis, 2011)
(Powell, 2011)
(Senior, Lee & Butler, 2011)
(Waldman, Balthazard & Peterson, 2011b)
(Waldman et al., 2011a)
(Balthazard, Waldman, Thatcher & Hannah, 2012)
(Boyatzis et al., 2012)
(Hills, 2012)
(Lee, Senior & Butler, 2012a)
(Lee, Senior & Butler, 2012b)
(Lindebaum, 2012)
(Powell & Puccinelli, 2012)
(Seni, 2012)
(Volk & Kohler, 2012)
(Ashkanasy, 2013)
(Becker & Menges, 2013)
(Bozionelos & Bozionelos, 2013)
(Butler, 2013)
(Cropanzano & Becker, 2013)
(de Holan, 2013)

(Koellinger et al., 2010)
(Nicolaou & Shane, 2010)
(Shane, 2010)
(Shane et al., 2010b)
(Shane et al., 2010a)
(van der Loos et al., 2010)
(Zhang & Ilies, 2010)
(Chaturvedi et al., 2011)
(Li, 2011)
(Nicolaou et al., 2011)
(Song et al., 2011)
(van der Loos et al., 2011)
(Cesarini et al., 2012)
(Chaturvedi et al., 2012)
(Judge et al., 2012)
(Li et al., 2012)
(Quaye et al., 2012a)
(Quaye et al., 2012b)
(Wernerfelt et al., 2012)
(De Neve, Mikhaylov, Dawes, Christakis & Fowler, 2013; Meyers, van Woerkom & Dries, 2013)
(Shane & Nicolaou, 2013)
(van der Loos et al., 2013b)
(Zyphur et al., 2013)
(Kong, 2014)
(Hansen, Larsen, Rugulies, Garde & Knudsen, 2009)
(Heraclides, Chandola, Witte & Brunner, 2009)
(Judge, Hurst & Simon, 2009)
(Shane, 2009)
(Sapienza, Zingales & Maestripieri, 2009)
(Unger et al., 2009)
(Wright, Cropanzano, Bonett & Diamond, 2009)
(Zyphur, Narayanan, Koh & Koh, 2009)
(Akinola, 2010)
(Ilies et al., 2010b)
(Ilies et al., 2010a)
(Mehta & Josephs, 2010)
(Sundararajan, 2010)
(Trahms et al., 2010)
(Voracek & Schicker, 2010)
(Agerstrom & Rooth, 2011)
(Guiso & Rustichini, 2011b)
(Guiso & Rustichini, 2011a)
(Jackson, Madewell & Kennison, 2011)
(Karlson et al., 2011)
(Saphire-Bernstein et al., 2011)
(Arvey & Zhen, 2012)
(Klofstad et al., 2012)
(Little & Roberts, 2012)
(Livingston, Rosette & Washington, 2012)
(Re et al., 2012)
(Halbesleben, Wheeler & Shanine, 2013)
(Hannah et al., 2013)
(Jack et al., 2013)
(Laureiro-Martinez et al., 2014)
(Lindebaum, 2013a)
(Lindebaum, 2013b)
(Lindebaum & Zundel, 2013; Scherbaum & Meade, 2013)
(Nicolaou & Shane, 2013)
(Senior & Lee, 2013)
(Tracey & Schluppeck, 2013)
(Waldman, 2013)
(Waldman et al., 2013)
(Waytz & Mason, 2013)
(Ashkanasy, Becker & Waldman, 2014)
(Boyatzis, 2014)
(Boyatzis, Rochford & Jack, 2014)
(Cikara & Van Bavel, 2014)
(Foxall, 2014)
(Healey & Hodgkinson, 2014)
(Krueger & Welpe, 2014)
(Lindebaum & Jordan, 2014)
(Lindebaum & Raftopoulou, 2014)
(McDermott & Hatemi, 2014)
(McDonald & Tang, 2014)
(Spector, 2014)
(Volk & Becker, 2014)
(Volk, Köhler & Pudelko, 2014)

(Spain & Harms, 2014)
(Colarelli & Arvey, 2015)
(Dimotakis & Schatten, 2015)
(Li et al., 2015)
(Lindquist et al., 2015)
(Schermer et al., 2015)
(Shane & Nicolaou, 2015b)
(Zyphur et al., 2015)
(Arvey et al., 2016)
(Belsky et al., 2016)
(Chi et al., 2016)
(Clark, Barney & Reddington, 2015)
(Hahn et al., 2016)
(Li et al., 2016b)
(Li et al., 2016a)

(Sherman et al., 2012)
(Spisak, Homan, Grabo & Van Vugt, 2012)
(Spisak, Dekker, Kruger & van Vugt, 2012)
(Spisak, 2012)
(Ganster & Rosen, 2013)
(Li & Xie, 2013)
(Re et al., 2013)
(Ronay & Carney, 2013)
(Scherbaum & Meade, 2013)
(van der Loos et al., 2013a)
(White, Kenrick & Neuberg, 2013)
(Alrajih & Ward, 2014)
(Arvey et al., 2014)
(Christian et al., 2014)
(Doll et al., 2014)
(Greene et al., 2014)
(Gundemir, Homan, de Dreu & van Vugt, 2014)
(Little, 2014)
(Olivola et al., 2014)
(Re & Perrett, 2014)
(Arvey & Zhang, 2015)
(Bendahan et al., 2015)
(Vongas & Al Hajj, 2015)
(Schipper, 2015)
(Unger et al., 2015)
(Klofstad et al., 2015)
(Bönte et al., 2015)
(Diebig et al., 2016)
(Gielen et al., 2016)

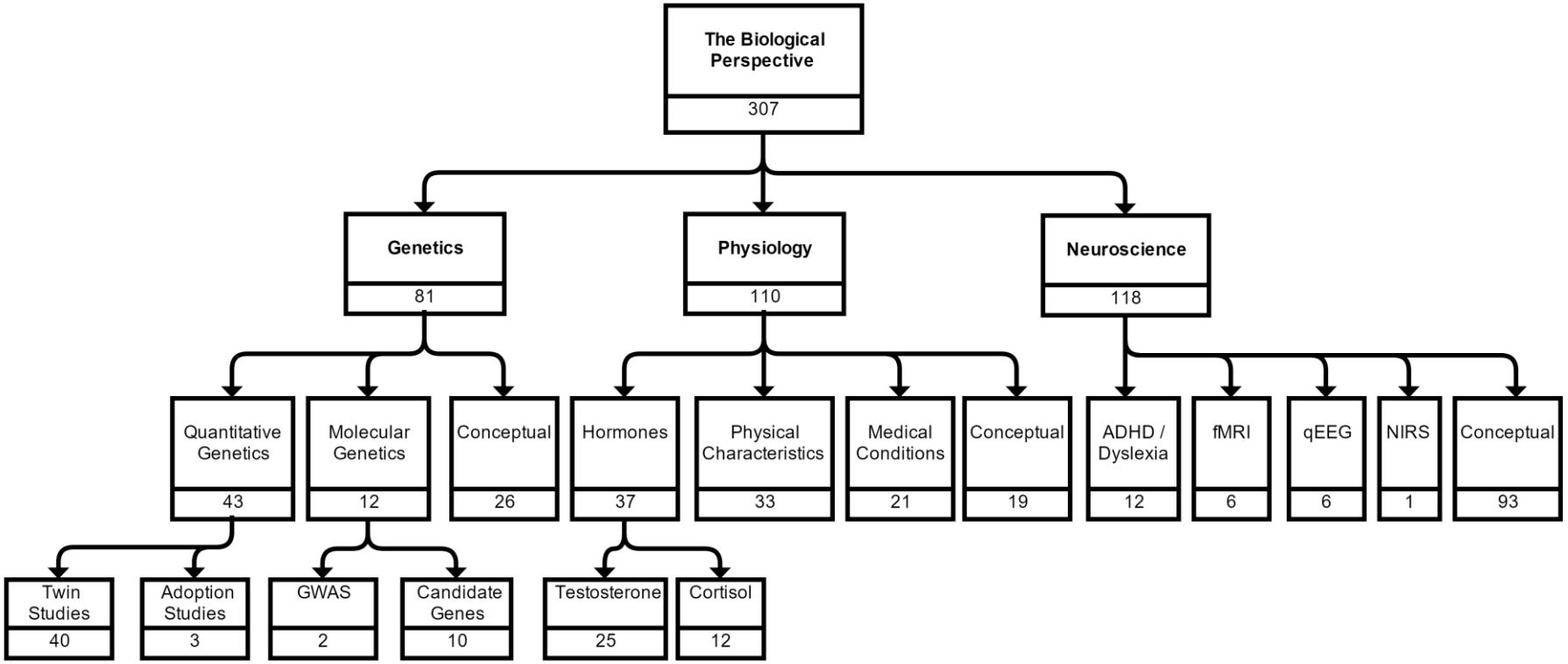
(Balthazard & Thatcher, 2015)
(Basnakova, van Berkum, Weber & Hagoort, 2015)
(Becker et al., 2015)
(Boyatzis, Rochford & Taylor, 2015)
(Case & Oetama-Paul, 2015)
(Coetzer, 2015)
(Friedman, Jack, Rochford & Boyatzis, 2015)
(Jackie, 2015)
(Jiang et al., 2015)
(Kawasaki et al., 2015)
(Laureiro-Martínez et al., 2015a)
(Laureiro-Martínez, Venkatraman, Cappa, Zollo & Brusoni, 2015b)
(Massaro, 2015)
(Molenberghs et al., 2015)
(Senior, Lee & Braeutigam, 2015)
(Verheul et al., 2015)
(Waldman & Balthazard, 2015b)
(Waldman & Balthazard, 2015a)
(Butler et al., 2016)
(Cropanzano, Massaro & Becker, 2016)
(Dulebohn et al., 2016)
(Healey, Hodgkinson & Massaro, 2016)

	(Klofstad et al., 2016) (Manville et al., 2016) (Nickson, Timming, Re & Perrett, 2016) (Overskeid, 2016) (Re & Rule, 2016a) (Re & Rule, 2016b) (Re & Rule, 2016c) (Sherman et al., 2016) (van der Meij, Schaveling & van Vugt, 2016) (Zak & Winn, 2016) (Nicolaou et al., in press) (Silberzahn & Menges, in press)	(Hoffman, 2016) (Lindebaum, 2016) (Niven & Boorman, 2016) (Robertson, Voegtlin & Maak, 2016) (Rochford, Jack, Boyatzis & French, 2016) (Thurik et al., 2016) (Verheul et al., 2016) (Waldman et al., 2016a) (Wiklund et al., 2016) (Waldman et al., 2016b) (Butler, Lee & Senior, In press) (Braeutigam, Lee & Senior, In press) (Waldman et al., in press)

*Complete references for the papers listed in Table 1 appear in the online appendix.

Figure 1

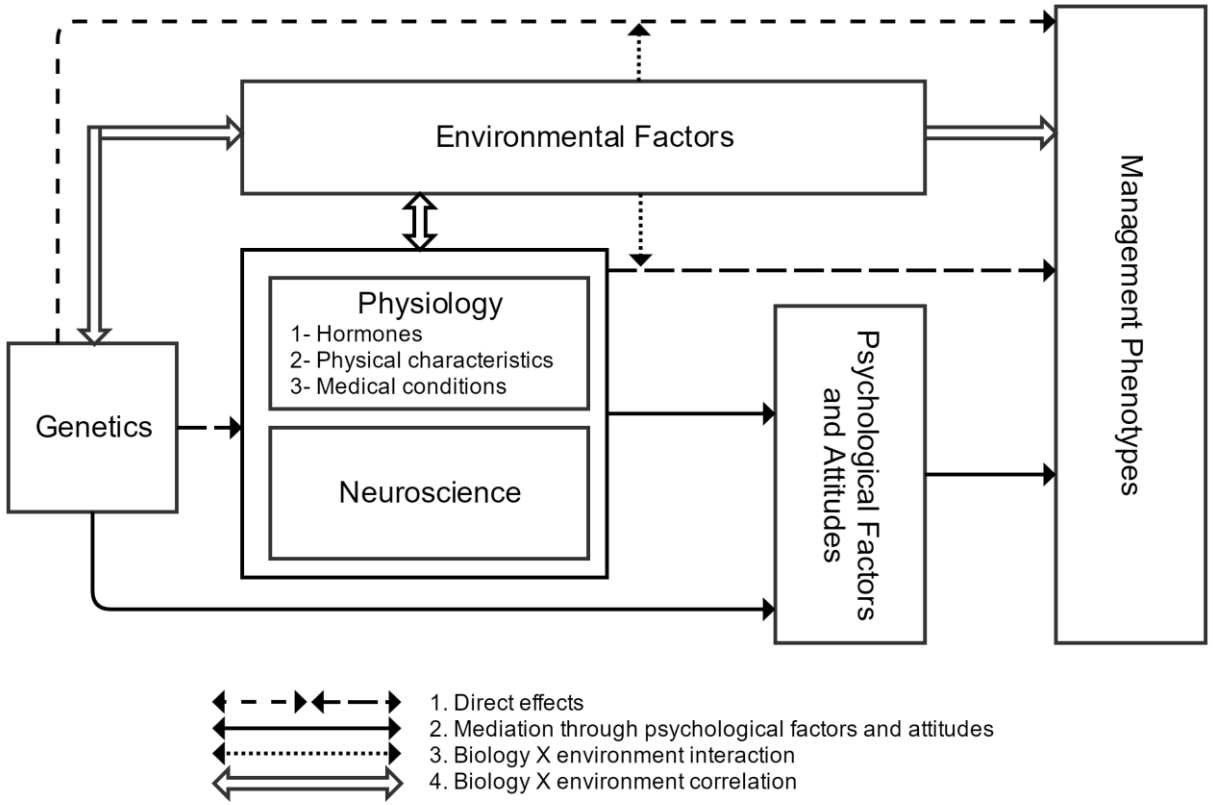
Organizing Framework*



* Some studies are included in more than one category. For example, the paper by Mehta and Josephs (2010) Is included in both the testosterone and cortisol sections as it examines both.

Figure 2

Theoretical Framework*



* The figure draws from Arvey and Bouchard (1994) and Arvey et al. (2014) and focuses only on biological influences on management. There are also interactions between biological factors such as gene X gene interactions and hormone X hormone interactions that are not described in the diagram